

Senile scleral plaques imaged with enhanced depth optical coherence tomography

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ABSTRACT.

Purpose: Senile scleral plaques (SSP) are sharply demarcated greyish areas located just anterior to the insertions of the horizontal rectus muscles and thus are frequently encountered during transscleral intravitreal injections. The aim of this study was to characterize SSP using enhanced depth imaging spectral domain anterior segment optical coherence tomography (OCT) in a cohort of patients attending intravitreal injection clinics.

Methods: Prospective cross-sectional study of 380 patients attending the clinic for intravitreal injections at the Department of Ophthalmology at the Bern University Hospital. Thirty-two patients with SSP were identified and the anatomical features were assessed using anterior segment OCT.

Results: In our patient cohort, we found a SSP prevalence of 8.2%. Senile scleral plaques were easily identifiable using anterior segment OCT and were found at the insertion sites of the horizontal recti muscles. The mean horizontal diameter was 2.2 mm ($\pm 760 \mu\text{m}$ SD), the mean vertical diameter was 3.3 mm ($\pm 144 \mu\text{m}$ SD), and the average surface area was 5.3 mm^2 ($\pm 0.4 \text{ mm}^2$ SD). The mean senile scleral plaque thickness was 0.6 mm ($\pm 149 \mu\text{m}$ SD). The mean distance from the limbus was 2.24 mm for nasally located SSP and 3.22 mm for temporally located SSP.

Conclusion: SSP are frequently encountered during intravitreal injections as they are located just anterior to the insertion sites of the horizontal recti muscles. Because the scleral stroma is rarefied and due to calcifications within SSP, these areas should be avoided when performing multiple intravitreal injections as this may result in rupture of the sclera.

Key words: anterior segment optical coherence tomography – sclera – senile scleral plaques

Acta Ophthalmol.

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doi: 10.1111/aos.12547

Introduction

With the introduction of anti-VEGF therapies for exudative age-related macular degeneration and macular oedema due to vein occlusion or diabetic maculopathy, intravitreal injections are nowadays routinely per-

formed in the clinic. During the injection process, the sclera is usually examined to find an adequate site for transscleral injection of the drug. One of the most common findings are focal demarcated greyish areas just anterior to the insertion of the horizontal recti muscles, called senile scleral plaques (SSP). Patients are usually asymptom-

atic and plaques are identified coincidentally on ophthalmic examination. The first description of senile scleral patches dates back to 1860 when Pagenstecher (Pagenstecher 1860) described calcified deposits in the area of the horizontal recti muscles in two post-mortem eyes. In 1959, Cogan provided a report of 25 patients with focal areas of scleral translucency and 30 post-mortem cases with senile scleral patches (Cogan & Kuwabara 1959). Histologically, SSP showed decreased cellularity and often contained calcifications. In our experience, the calcifications within SSP can impede penetration of the needle during transscleral intravitreal injections. Furthermore, the thinning of the scleral stroma in the area of SSP may predispose to rupture when subjected to repeated transscleral injections. The frequent finding of SSP in patients undergoing intravitreal injections and their location in the area of the injection site led us to revisit SSP using enhanced depth imaging (EDI) anterior segment optical coherence tomography (OCT) and to assess their prevalence and anatomical characteristics.

Materials and Methods

The study conformed to the provisions of the Declaration of Helsinki and was approved by the local ethics committee. In July 2013, all patients attending the clinic for intravitreal injections at the Department of Ophthalmology at the University Hospital Bern, Switzerland were screened for senile scleral patches (SSP). General medical history and informed consent was obtained from all patients.

Imaging and image analysis

For clinical documentation, the area of scleral translucency was photographed using a slit lamp mounted camera (Canon EOS 7D; Canon, Wallisellen, Switzerland). The colour photos were taken with a resolution of 2592×1728 (4.5 MP). For OCT imaging a spectral domain anterior segment OCT (Heidelberg Engineering, Dossenheim, Germany) was used and the sclera mode with EDI was chosen with an OCT grid of 21×21 lines each measuring 8.1 mm. The SD-AS-OCT pictures were taken with a resolution of 768×496 (381 KB) and a scan angle of 15° . In primary gaze position, the SSP were too posterior in relation to the AS-OCT detector to be scanned. Therefore, guided by a fixation light, the patients were asked to make either a 45° temporal or nasal gaze for imaging of the nasal and temporal scleral quadrants. This allowed for perpendicular OCT imaging of SSP.

Using the HEIDELBERG EYE EXPLORER software (version 1.7.1.0; Heidelberg Engineering, Dossenheim, Germany), the distance from the scleral spur (SS) to the anterior border of the senile scleral plaque, maximal horizontal and vertical diameter and height of the SSP were measured. Furthermore, the thickness of the scleral wall in the area of the plaque and the surface area was measured. The SS was either detected directly on OCT or indirectly with the Schwalbe's line method (Seager et al. 2013).

To determine the statistically significant differences, the unpaired two-tailed Student's *t*-test was used. *p* values <0.05 were considered statistically significant. Statistical data analysis was performed using GRAPH-PAD PRISM version 5 for Windows (GraphPad Software Inc., La Jolla, CA, USA).

Results

In July 2013, 380 patients at the clinic for intravitreal injections at the Department of Ophthalmology at the University Hospital Bern, Switzerland were screened for SSP. Of these Patients, 32 were identified with at least one SSP (8.2%). Eleven patients presented with only one SSP, seven patients presented with seven SSP, seven patients pre-

sented with three and seven patients presented with four SSP.

In total, 62 eyes with a total of 74 SSP were included for characterization. The mean age of the patients was 85.0 years [± 5.3 years standard deviation (SD); interquartile range (IQR), 81–90 years]. The mean refractive error was $+0.8$ D (IQR, ± 0.0 to $+1.5$ D). The female to male ratio was 27:5. Senile scleral plaques were exquisitely located at the insertion sites of the

horizontal recti muscles (Fig. 1A a–e). Some SSP were easily identifiable (Fig. 1A a–f) while others were less distinctive. They were more common in the nasal quadrant than in the temporal quadrant (Fig. 1B) with an average of 1.5 patches in the former and 0.8 patches in the latter per patient.

Next, we measured the SSP in vertical (Fig. 2A) and horizontal (Fig. 2B) OCT sections and from both sections, we calculated the thickness of SSP. The

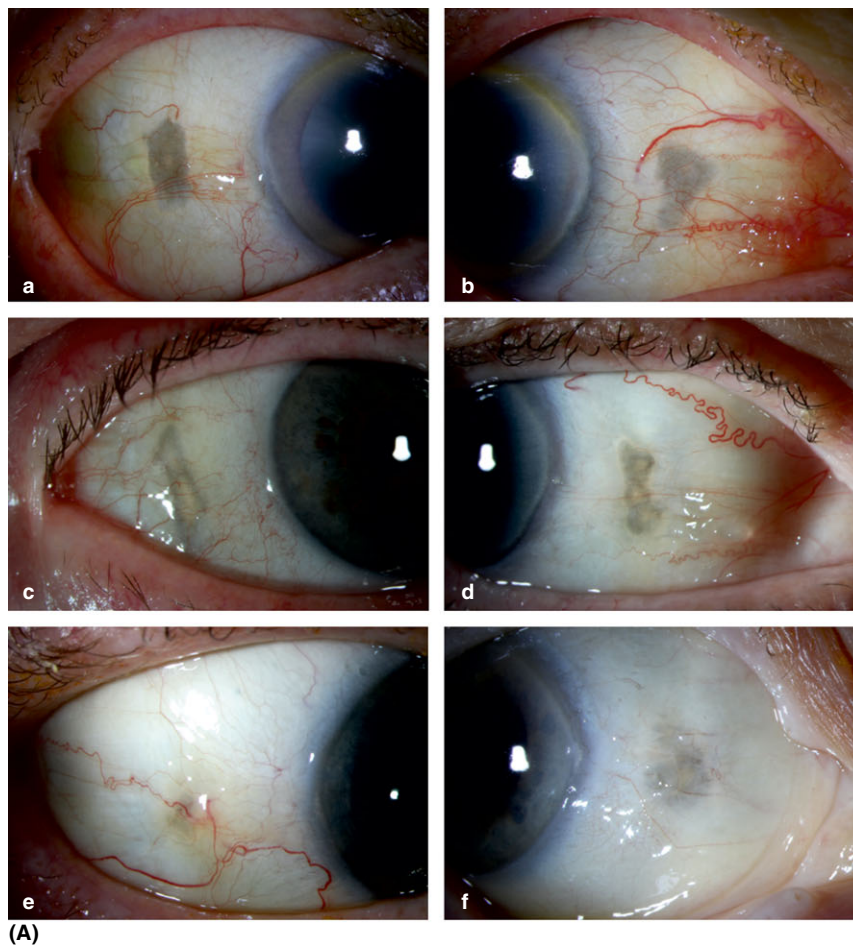


Fig. 1. Distribution of senile scleral plaques (SSP) with various degrees of prominence. (A) Colour slit lamp images of SSP. (a, c and e are representative images of temporal SSP and b, d and f of nasal SSP. (B) Bar graph of SSP prevalence for the nasal and temporal quadrant per patient ($n = 32$, values represent average number of patches \pm SEM, *** $p < 0.001$).

SSP were easily identifiable in OCT sections as were the individual components of the scleral wall (Fig. 2C). The

mean thickness of SSP was $577 \mu\text{m}$ ($\pm 149 \mu\text{m}$ SD) (Fig. 3A). The mean horizontal, or limbus parallel, diameter

of SSP was $2274 \mu\text{m}$ ($\pm 760 \mu\text{m}$ SD). The vertical diameter for the nasally located SSP was $3063 \mu\text{m}$ ($\pm 177 \mu\text{m}$ SD) and for the temporally located $3730 \mu\text{m}$ ($\pm 349 \mu\text{m}$ SD) (Fig. 3B). Senile scleral plaques had an average surface area of 4.8 mm^2 ($\pm 0.4 \text{ mm}^2$ SD) nasally and 6.4 mm^2 ($\pm 0.8 \text{ mm}^2$ SD) temporally (Fig. 4-1).

In all cases, the lateral rectus muscle was well demarcated in OCT (Fig. 4-2A). The mean distance from the limbus was 2.24 mm for nasally located SSP and 3.22 mm for temporally located SSP (Fig. 4-2).

Discussion

Senile scleral plaques are a frequent finding in the elderly population with a prevalence of approximately 8.2%. Here, we describe OCT features of SSP in patients undergoing anti-VEGF therapy. Although SSP are a common finding in patients aged 70 and above, a detailed characterization has not been done so far. Using the slit lamp, most SSP are readily distinguishable (Fig. 1). The prevalence of SSP has been reported to be between 3% (aged 60) and 25% (aged 80 or more) with a female preponderance in a large clinical study where 1086 outpatients have been screened (Norn 1974). Several studies

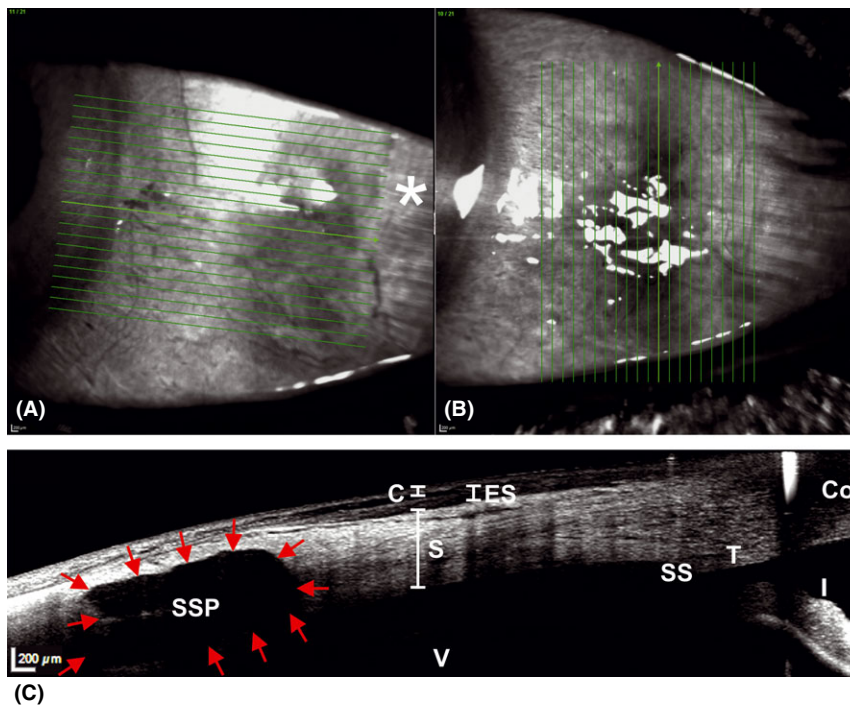


Fig. 2. Anterior segment optical coherence tomography (OCT) imaging of the sclera. (A) horizontal sections through the senile scleral plaque (the rectus muscle is marked with an asterisk) and (B) vertical sections. (C) Representative OCT image of the sclera where Co = cornea; C = conjunctiva; ES = episclera; S = sclera; V = vitreous cavity; SSP = senile scleral plaque; SS = scleral spur; T = trabecular meshwork and I = Iris; (scale bar $200 \mu\text{m}$). Red arrows delineate border of senile scleral plaque.

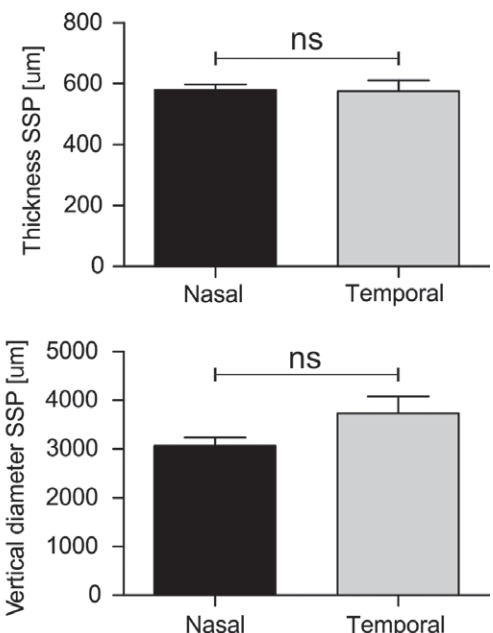
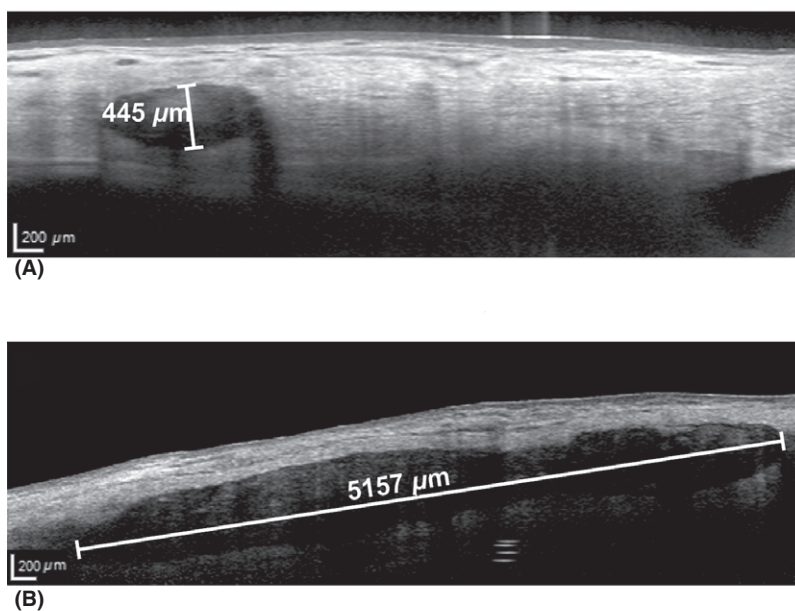


Fig. 3. Size of scleral senile patches. (A) Representative optical coherence tomography (OCT) image showing the measurement of the thickness of senile scleral plaque and bar graph showing mean \pm SEM for nasal and temporal scleral plaques ($n = 32$, ns = not significant). (B) Representative OCT image showing the measurement of the maximal horizontal extent of scleral plaques and bar graph showing mean horizontal extent for nasal and temporal senile scleral plaques ($n = 32$, ns = not significant, all with scale bar $200 \mu\text{m}$).

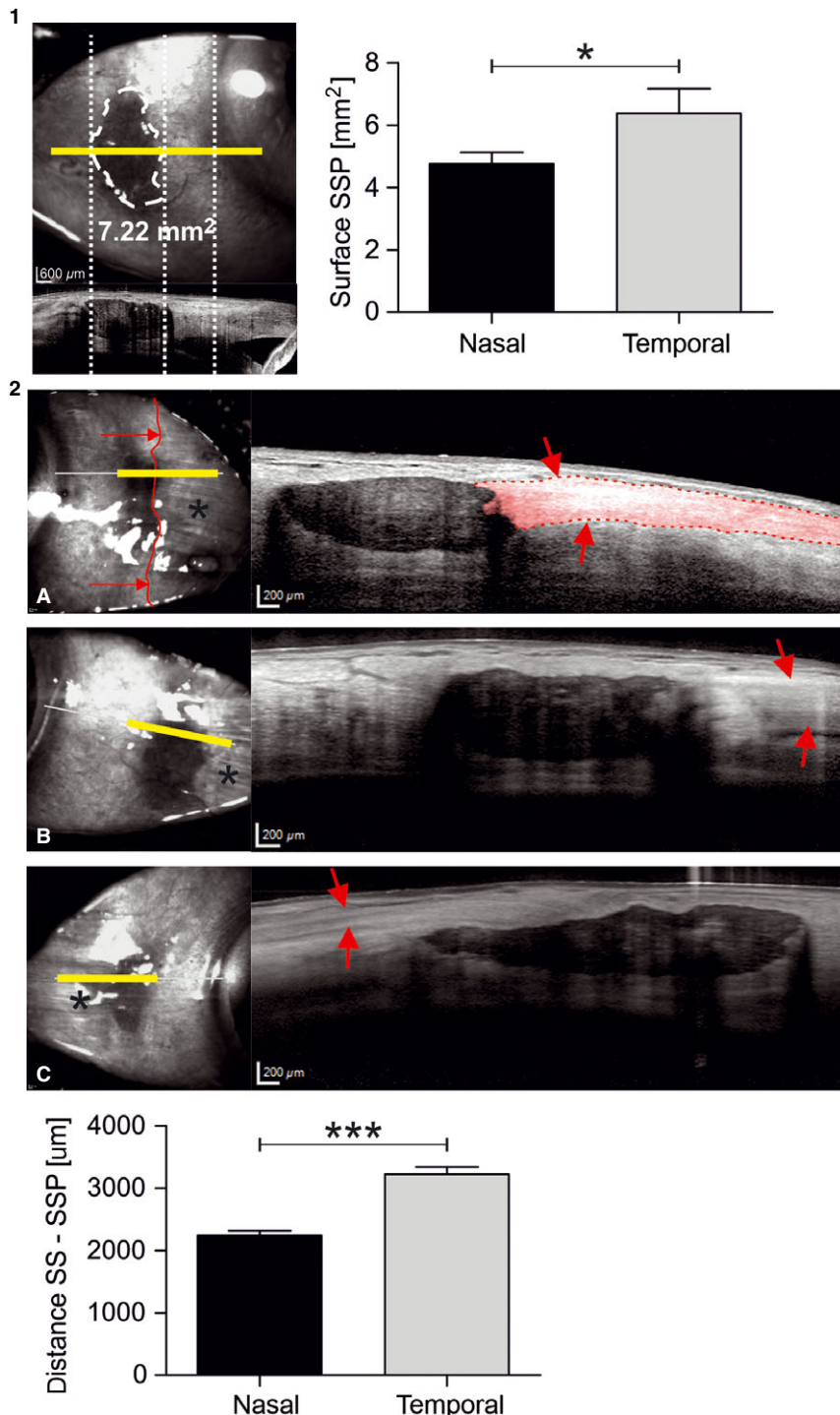


Fig. 4. (1) Average surface area and (2) location of sclera senile patches in relation to the insertion of the horizontal recti muscles. (1) The surface area of the sclera translucency was measured using the infrared images (top) which were colocalized (dotted lines) with the optical coherence tomography (OCT) images (bottom, scale bar 200 µm). (2) (A) Muscle insertion marked red in the infrared image and the OCT to show the transition from the muscle insertion to a scleral plaque. (B, C) Representative infrared (left) and OCT images (right, all scale bar 200 µm). The scan line has been enhanced from the original for better visualization. The rectus muscle is marked with a black asterisk in the infrared image and delineated with red arrows in the OCT image. Bar graph (bottom) of average distance ± SEM from scleral spur to the senile scleral plaque ($n = 32$, * $p < 0.05$, *** $p < 0.001$).

have reported a similar incidence. Radiological studies using computed tomography have found a prevalence of

calcified scleral plaques in the range of 20% in patients 80 years old or older. This higher incidence may be due to the

fact that calcifications may be present in the sclera without overt SSP (Moseley 2000).

In our cohort, we found cases that were very difficult to see against the scleral background but were clearly visible on OCT scans (Fig. 2). Furthermore, we did not find any association with systemic diseases affecting the sclera such as autoimmune diseases. In our cohort, temporal SSP were located on average 3.22 mm from the limbus meaning that many SSP would be encountered when choosing an injection site 3.5 mm from the limbus. In contrast to an earlier report on limbus-insertion distance of the horizontal recti muscles using anterior segment OCT where the authors used the anterior chamber angle as landmark for measurements (Liu et al. 2011), we used the SS as landmark to measure the limbus to SSP distance. This may explain the shorter distances to the muscle insertion when adding the average distance from the limbus to SSP and the horizontal diameter of the SSP. In our cohort, this resulted in a limbus to medial rectus muscle insertion distance of 4.6 mm and limbus to lateral rectus muscle insertion of 5.4 mm.

Two salient features of SSP in OCT merit further discussion. In the first instance, we were able to show that SSP display as a hyporeflective structure in OCT and that calcifications are readily visible as hyper-reflective structures. Secondly, we report for the first time the close association of the plaques with the rectus muscle insertions. The human sclera is composed of dense, primarily collagenous tissue consisting mainly of types I, III, V and VI collagen (Meek & Fullwood 2001). Collagen provides rigidity while being metabolically relatively inert. The sclera performs several important functions for the visual integrity of the eye. It not only provides protection to the intraocular contents but also ensures that internal light scattering does not affect the retinal image by its opacity. Furthermore, the sclera provides support for the powerful extraocular muscles to rotate the eye without distortion. We can only speculate about the pathomechanisms causing SSP. However, the finding of the SSP always being in close association with the muscle insertions may point towards a mechanical aetiology. The peculiar location of SSP at the inser-

tion sites of the horizontal recti muscles may be explained by the fact that these muscles are stronger (Collins et al. 1981) and used more often than the other recti muscles for accommodation and horizontal eye movements. Furthermore, the medial rectus muscle has been shown to be stronger than the lateral rectus muscle (Collins et al. 1981), possibly explaining the higher prevalence of medial SSP. Hypocellularity within the collagenous tissue at the insertion site of other muscle tendons, such as the gastrocnemius muscle, is also found in a condition called tendinosis.

However, the lateral and medial location would also support the hypothesis that SSP are influenced by exposure to air as they are the only muscle insertions exposed by the palpebral fissure. A view that has been suggested in an earlier report (Gasteiger 1937). In contrast to focal necrotizing scleritis, there is no perifocal clinical inflammation in SSP, and patients are asymptomatic supporting the view that inflammation does not play a role in the pathogenesis of SSP.

Anterior segment OCT imaging is increasingly used beyond the cornea and the anterior chamber angle to image structures such as the sclera (Theelen & Hoyng 2013). With the increased use of transscleral intravitreal

application of biologicals for retinal disease, a better understanding of scleral pathologies is desirable. Repeated injections in this area may lead to rupture of the sclera a finding which has been reported to occur spontaneously in SSP (Marker et al. 2011). Our OCT findings suggest that the scleral stroma is thinned in SSP and thus may represent a weak area in the scleral architecture, which may lead to rupture when chosen as site for repeated intravitreal injections.

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Received on January 18th, 2014.

Accepted on July 28th, 2014.

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